REPORT #
RRTAC 90-2

Initial Selection for Salt Tolerance in Rocky Mountain Accessions of Slender Wheatgrass and Alpine Bluegrass

Heritage Fund

Alberta

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RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

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This report may be cited as:

Hermesh, R., J. Woosaree, B.A. Darroch, S.N. Acharya and A. Smreciu, 1990. Initial selection for salt tolerance in rocky mountain accessions of slender wheatgrass and alpine bluegrass. Alberta Land Conservation and Reclamation Council Report No. RRTAC 90-2. 40 pp.

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INITIAL SELECTION FOR SALT TOLERANCE

IN ROCKY MOUNTAIN ACCESSIONS

OF SLENDER WHEATGRASS AND ALPINE BLUEGRASS

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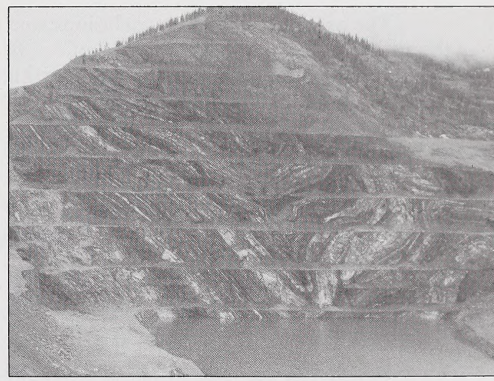
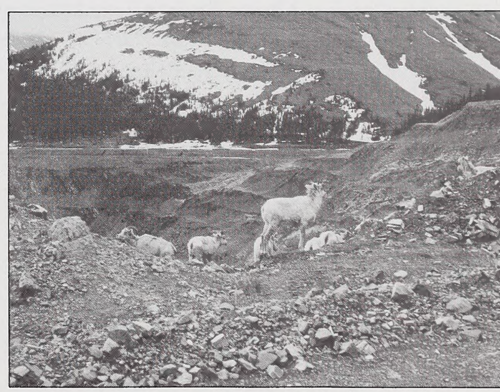
ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL
(Reclamation Research Technical Advisory Committee)

The Reclamation Research Technical Advisory Committee is grateful to the Alberta Environmental Centre for co-funding this research.

1990

Mountains and Foothills Reclamation Research Program





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DISCLAIMER

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

The opinions, findings, conclusions, and recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of government or industry. Mention of trade names or commercial products does not constitute endorsement, or recommendation for use, by government or industry.

REVIEWS

This report has been reviewed by members of the Reclamation Research Technical Advisory Committee and the Mountains and Foothills Reclamation Research Program Committee. Mr. Doug Beddome, Alberta Environment, Land Conservation and Reclamation Council, and staff of the Plant Sciences Division, Alberta Environmental Centre, also reviewed the report.

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Funding for this project was provided by the Alberta Heritage Savings Trust Fund, Land Reclamation Program which is administered by the Reclamation Research Technical Advisory Committee of the Alberta Land Conservation and Reclamation Council, and from the Alberta Environmental Centre in Vegreville. The authors wish to thank the Canadian Parks Service for their support of this work and for permitting collections of test material from Waterton, Banff, Jasper and Yoho National Parks.

ABSTRACT

Collections of slender wheatgrass (*Agropyron trachycaulum* (Linke) Malte) and alpine bluegrass (*Poa alpina* L.) from alpine and subalpine regions of Alberta's Rocky Mountains and foothills were screened for their ability to emerge in a saline medium. Screening was done using vermiculite saturated with a one-half strength Hoagland's solution salinized with NaCl to yield a conductivity of 15 mS/cm. After 21 days of imbibition, 11 slender wheatgrass and 72 alpine bluegrass lines had a higher percentage emergence than the Orbit tall wheatgrass (*Agropyron elongatum* (Host) Beav.) control. Accessions found tolerant to high concentrations of NaCl were also tolerant of other salts; however, overall emergence was lowest in a NaCl salt solution,. The ability to emerge in a salinized nutrient solution was found to be moderately heritable (h^2=68%) in slender wheatgrass, but was not tested in alpine bluegrass.

1. INTRODUCTION

Increasing natural and man-caused salinization of productive range and wildlands is becoming a major concern in the Rocky Mountains and foothills of southern Alberta (Leskiw 1988). Soil salinity can become a problem by affecting plant growth when the electrical conductivity (EC) exceeds 4 mS/cm. Above 16 mS/cm, there is little crop growth (Alberta Soils Advisory Committee 1987). Local plant varieties adapted to saline materials could prove effective in the reclamation of salinized sites. Alpine bluegrass (*Poa alpina* L.)* and slender wheatgrass (*Agropyron trachycaulum* (Linke) Malte) have potential for reclaiming disturbed sites (Hardy BBT Limited 1989; Sadasivaiah et al. 1978; Sutton 1975; Walker 1979). Although these grass species are not particularly salt tolerant, screening might find salt tolerant accessions among collections held at the Alberta Environmental Centre (AEC). If found, salt tolerant accessions could be tested for use in revegetating saline soils in special problem areas, such as roadsides and industrial disturbances (Greub et al. 1979).

In 1987/88 the Vegetation Branch at AEC began to screen slender wheatgrass and alpine bluegrass collections for salt tolerance. As a first step, a screening method selected from the literature was tested by screening standard agronomic varieties to determine if results were consistent with published salt tolerances. The next step was to screen the slender wheatgrass and alpine bluegrass collections at AEC to compare their emergence from a saline rooting medium with that of a standard agronomic control. The work was initially supported by the Alberta Business and Community Development (ABCD) Program which provided four man-years of technical support. By the time the ABCD Program ended in October 1988 encouraging results

*Scientific Names from Moss 1983.

had been obtained. The Reclamation Research Technical Advisory Committee (RRTAC) then provided funding to continue this work. The objective of this project was to determine if there was adequate genetic variability in salt tolerance among available accessions of slender wheatgrass and alpine bluegrass to ensure the success of a breeding program. Specifically the study:

1. modified a screening method;
2. screened existing collections at AEC for their ability to emerge in a salinized medium;
3. determined if a plant's tolerance to one salt also indicates tolerance to other common salts; and,
4. determined if heritability of salt tolerance in slender wheatgrass is sufficient to justify a breeding program.

2. LITERATURE REVIEW

Evidence for varietal differences in salt tolerance of slender wheatgrass has steadily accumulated since the systematic studies of Dewey (1960, 1962). To select for salt tolerance, the germplasm from which selections can be made must be acquired by making collections from salt affected areas (Rana 1985). Many authors have sought to develop a rapid and reliable technique to isolate salt resistant genotypes and exploit the existing variability (Jana et al. 1980; McKimmie and Dobrenz 1987; Schaller et al. 1981; Shannon 1977, 1979; Wrona and Epstein 1980). The first possible stage for selection is at germination. For forage grasses, screening and selection at the seedling stage seems to be a practical method of developing resistant cultivars which are able to grow in highly saline soils without an accompanying loss of yield under normal conditions. Ashraf et al. (1986) showed conclusively that a genetically based increase in tolerance to NaCl could be achieved through selection in four grass species. They also drew attention to the great potential of using seedling screening techniques in the production of salt-tolerant genotypes. Selection of genotypes which have the ability to germinate in salt affected soils is important since high salt concentrations both delay and decrease germination and emergence (Mueller and Bowman 1989). The salt tolerance of seedlings may be highly predictive of the response to salinity of adult plants (Blum 1985; Greenway 1965), however, in some cases the same plant may have quite different salt tolerances at different life stages (Kingsbury and Epstein 1984; Shannon 1979).

Early methods of screening seedlings involved germinating seeds in petri dishes between blotters or filter papers wetted with a salt solution (NaCl or $CaCl_2$) (Dotzenko and Haus 1960). However, micro-environmental variations in the petri

dish caused localized evaporation or condensation resulting in variable exposure of the seed to salinity stress (Blum 1988). More recent studies have used plants grown in sand or gravel (Ashraf et al. 1986; Blum 1988; McKimmie and Dobrenz 1987), hydroponic techniques (Kingsbury and Epstein 1984, Wrona and Epstein 1980), or salinized agar media (Torello and Symington 1984). Jana et al. (1980) evaluated germination in barley accessions using styrene seeding tubes placed in rectangular plastic boxes filled with sterile vermiculite. The vermiculite was saturated with a one-half strength Hoagland's solution salinized with sodium chloride. Seeds were then sown in the tubes and covered with 5 mm of vermiculite. McKimmie and Dobrenz (1987) developed a salt box method to select alfalfa accessions at germination, emergence and establishment. A plywood box 10 cm deep was partly filled with salinized one-third strength Hoagland's solution. Fresh solution was circulated by a pump from an adjacent reservoir. Nursery flats were placed into the box and filled with fine vermiculite.

The estimation of heritability (h^2) of a trait provides information on its potential for improvement through selection - the higher the heritability, the greater the potential to improve the trait. In the broad sense, heritability is the ratio of genetic variance to total phenotypic variance (Falconer 1981). Narrow sense heritability refers to the ratio of additive genetic variance to phenotypic variance and is a more accurate measure of the degree to which a trait can be modified by selection. Realized heritability of a trait is determined after selection by comparing the observed response to selection to the selection differential (the difference between the selected population and the overall population; Falconer 1981). Realized heritability may differ from other measures of heritability because it is primarily a description of the response to selection. However, it does provide an estimate of

heritability within a population and an indication of the potential for further improvement in the trait by selection.

Very little research has been done on the heritability of salt tolerance in perennial grasses but heritability estimates in other species have been reported. Jones and Stenhouse (1984) estimated broad sense heritability of salt tolerance in rice to be 49.2% to 83.3%. Moeljopawiro and Ikehashi (1981) reported values of 78% to 89% in mangrove rice, whereas realized heritability was estimated to be 39% to 62%. Allen et al. (1985) measured salt tolerance in alfalfa by germinating seeds in NaCl solutions and found an average broad sense heritability of 50%. Narrow sense heritability for salt tolerance in cucumber ranged from 41% to 86% (Jones 1984) and an estimate of 38% was observed for cotton (Ledbetter 1986). Norlyn (1980, 1984) studied yield of barley under saline conditions and found it to be heritable with h^2=28%. These values show that salt tolerance is moderately heritable and it should be possible to improve salinity tolerance by selection.

3. MATERIALS AND METHODS

3.1 EXPERIMENT 1 COMPARING AGRONOMIC VARIETIES

A method to evaluate salt tolerance at emergence, modified after Jana et al. (1980) and McKimmie and Dobrenz (1987), was used to compare emergence in 12 agronomic varieties with known salt tolerances at three salt concentrations. Comparisons were conducted using Hillson Sixes root-trainers with 96 cells arranged in six rows by sixteen columns. A layer of cheese cloth was placed at the bottom of the root-trainers. Medium sterile vermiculite was placed 9 cm deep in each cell. The assembled root-trainers were placed into plastic trays 30 by 40 by 10 cm. One-half strength Hoagland's solution was salinized with analar sodium chloride (NaCl) to yield solutions with electrical conductivities (EC) of 10, 15 and 20 mS/cm. Four and one-half litres of freshly prepared salt solution was added to each tray, sufficient to keep the tray half full and saturate the vermiculite to the surface. Salinity of the solution was measured using a YSI Model 32 conductivity meter. As EC is related directly to the concentration of soluble salts in the solution, the method provides an index of salt concentration; the higher the EC, the higher the salt concentration (Bernstein and Francois 1973; Maas and Hoffman 1977).

Varieties (Subplots) were compared using a split plot design with two replicates. The seeded trays were placed into a growth chamber set to a 22/15°C temperature regime, with a 16 h photoperiod and a light intensity of 285 $uEm^{-2}s^{-1}$, at the warmer temperature. Distilled water (300 ml) was added daily to each root- trainer tray to keep the water levels and salt concentrations constant. Salts concentrated at the surface of the vermi- culite were washed down twice a week with the solution from the root-trainer trays. Conductivity of the solutions was checked weekly. Emergence was recorded thrice weekly for 3 weeks.

3.2 EXPERIMENT 2 SCREENING SEED COLLECTIONS

This experiment screened AEC collections of 406 slender wheatgrass and 1441 alpine bluegrass accessions for emergence in a saline medium. The accessions originated from tussocks collected from 315 sites throughout the Rocky Mountains and foothills between Waterton National Park and Jasper townsite (Figure 1). Sites ranged in elevation from 1100 m to 2750 m. At each site, tussocks were collected within a 10 m radius. Collected tussocks were placed in plastic bags and stored on ice a maximum of 3 days while being transported to AEC. They were then transplanted into 12 cm fiber pots and placed into growth chambers set to cycle at 22/15°C temperatures, with a 16 h photoperiod. After 14 days in growth chambers, the plants were moved outside to harden-off for an additional 14 days before being transplanted to a field nursery. Seeds used in the experiments were harvested from this nursery.

Based on results of initial work described in Experiment 1, collections were screened at an EC of 15 mS/cm and tall wheatgrass (Orbit) (Agropyron elongatum (Host) Beav.) was used as the control. Screening was conducted using the method described for Experiment 1. To ensure uniform germination and to overcome any possible dormancy problems all wheatgrass seeds, including Orbit, were dehulled. All accessions were tested in groups of 48 using a randomized complete block design (RCBD) with three blocks for each group. In each root-trainer, five cells in each column comprised the test line, while the control was seeded across the centre row. Two seeds of the test accession were planted in each cell while the control had one seed per cell. The seeds were covered with approximately 0.5 cm of vermiculite. After 21 days, accessions which emerged equal to or better than the control were selected and transplanted into 15 cm pots containing a soil mix and grown to increase seeds of the selected accessions.

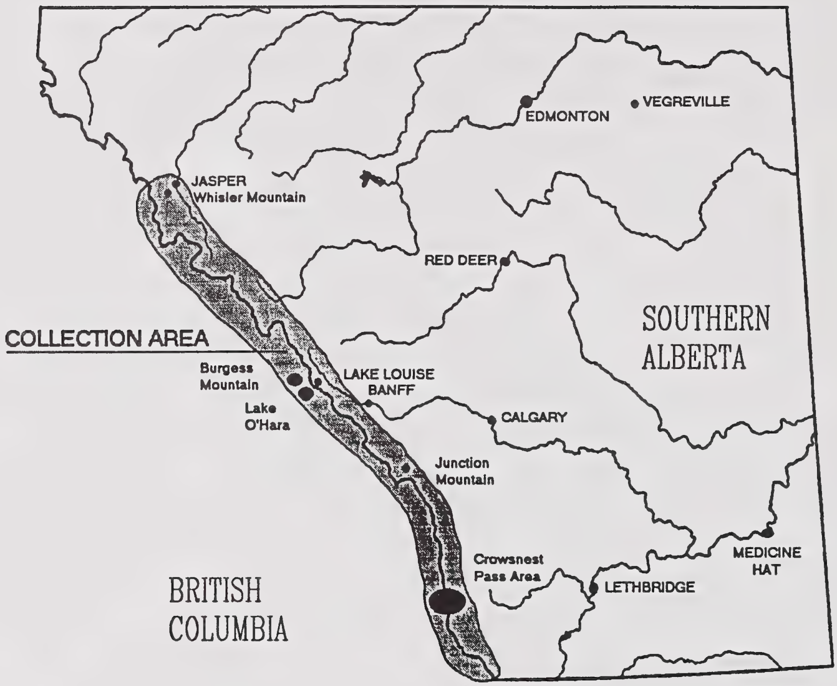

Figure 1. Geographic origin of AEC collections and provenance of selected accessions.

3.3 EXPERIMENT 3 SALINITY TESTS

Much of the literature on screening for salt tolerance involves evaluating plants using various concentrations of NaCl (Blum 1988) because this salt is commonly associated with irrigated soils. In the screening conducted in Experiment 2 it was assumed that accessions tolerant to high levels of NaCl were probably also tolerant to other salts. However, salinity in Alberta soils generally results from mixtures of sodium sulphate (Na_2SO_4), magnesium sulphate ($MgSO_4$), and calcium chloride ($CaCl_2$) at various concentrations (Alberta Agriculture 1985). This experiment was undertaken to compare the tolerance to these salts of the accessions previously selected for their tolerance to NaCl. Comparisons were conducted using one-half strength Hoagland's solution salinized with analar NaCl, Na_2SO_4, $MgSO_4$, and a mixture of salts made up of a ratio by weight of 5 Na_2SO_4 : 2.5 $MgSO_4$: 1 $CaCl_2$, to yield a solution with an EC of 15 mS/cm in each case. Table 1 shows the amount of salt per litre and molarity required for a 15 mS/cm solution.

In each salt solution, the emergence of six selected and eight randomly picked but not-selected accessions of slender wheatgrass was compared to tall wheatgrass (Orbit) and slender wheatgrass (Revenue) controls. The experimental design was a split plot with six replicates (blocks) placed within two growth chambers. Results were subject to a fixed effects analysis of variance. Comparisons of cumulative emergence were made among treatments at the end of 21 days using the Ryan-Einot-Gabriel-Welsh multiple F test (REGWF), at alpha = 5%. Each replicate comprised ten seeds placed two per cell in five cells across the root-trainer. Tests were set up and evaluated and the growth chamber environment was controlled as described for Experiment 1.

Table 1. Molarity of different salts required to make a solution with a conductivity of 15 mS/cm.

Salt	Salt Added (g/L)	Molarity	Conductivity mS/cm
$MgSO_4$	47.5	0.19	15
Na_2SO_4	15.1	0.11	15
NaCl	9.4	0.16	15
Mixture[1]	25.0	0.13	15

[1] 5 Na_2SO_4:2.5 $MgSO_4$:1 $CaCl_2$

3.4 EXPERIMENT 4 PROGENY TESTS

During initial screening of 406 slender wheatgrass accessions (Experiment 2), 11 accessions with emergence counts (after 21 days) greater than Orbit were selected as being salt tolerant. Seeds from the same accessions as the selected plants were multiplied in greenhouse soil beds. Seeds harvested from these plants were used in progeny tests. Emergence of second generation seeds of all selected accessions was compared to emergence of Orbit under saline conditions using the method described for initial screening (Experiment 2). A randomized complete block design with six replicates was used.

Realized heritability of salinity tolerance was estimated as follows (Falconer 1981):

$$h^2 = R/S$$

where R = response to selection

and S = selection differential.

The selection differential was calculated as the difference between the mean of the selected accessions and the mean of the entire population of slender wheatgrass lines. The response to selection was calculated in the same way but was based on data from the second generation. It was assumed that the mean of the whole population was the same in the first and second generations. To reduce the effect of environmental differences between generations, all values were expressed as a percent of Orbit. The standard error of realized heritability was estimated by dividing the standard error of response by the selection differential.

4. RESULTS

4.1 EXPERIMENT 1 COMPARING AGRONOMIC VARIETIES

Significant differences in salt tolerance at emergence were observed when emergence of 12 agronomic varieties was compared in a salinized salt medium (Table 2). The results were consistent with expectations based on the published tolerances (Greub et al. 1979; Maas 1984). These results showed that the method used was an indicator of salt tolerance during emergence. Tall wheatgrass (Orbit) had significantly higher ($p<0.05$) percentage emergence at all salt concentrations tested. Therefore, Orbit was chosen as the control against which accessions of slender wheatgrass and alpine bluegrass were compared. The nutrient solution salinized to 15 mS/cm EC with NaCl was considered adequate to identify salt stress tolerant accessions. At this concentration, mean emergence of all cultivars was still over 50%, the range of emergence was wider than at 10 mS/cm EC and Orbit emergence was not adversely affected.

4.2 EXPERIMENT 2 SCREENING SEED COLLECTIONS

Eleven of 406 accessions of slender wheatgrass (3%), had a percent emergence in a 15 mS/cm solution of NaCl better than the Orbit control and were selected as potentially having a high salt tolerance. Of the 1441 accessions of alpine bluegrass screened, 72 accessions (5%) were selected.

Although collections were made from 315 sites throughout the east slopes of the Rocky Mountains, of the 11 wheatgrass accessions selected, 10 originated from the Crowsnest Pass area of Alberta (Table 3; Figure 1). The one exception came from Whistler Mountain near Jasper. Of the 72 selected accessions of alpine bluegrass, 29 originated from the Crowsnest Pass area, while 42 originated from the Burgess Mountain-Lake O'Hara-Lake Louise area. The one exception came from Junction Mountain

Table 2. Mean percent emergence (N=2) after 21 days of 12 agronomic grass varieties at three salt concentrations.

		Mean Percent Emergence		
Common name	Variety	10 mS/cm	15 mS/cm	20 mS/cm
Tall wheatgrass	Orbit	88	92	75
Russian wildrye	Cabree	71	67	58
Brome	Carlton	50	38	46
Northern wheatgrass	Elbee	67	63	38
Crested wheatgrass	Parkway	63	38	38
Western wheatgrass	Walsh	54	33	33
Creeping red fescue	Boreal	54	50	29
Timothy	Climax	50	54	29
Altai wildrye	Praireland	38	54	29
Intermediate wheatgrass	Clarke	54	42	25
Kentucky bluegrass	Nugget	38	33	25
Slender wheatgrass	Revenue	46	42	13

Table 3. Site, plant identification, mean emergence (N=3) in a 15 mS/cm solution of NaCl (expressed as a percent of Orbit tall wheatgrass control) and description of original collection site of selected accessions of slender wheatgrass.

SITE ID.	PLANT ID.	EMERGENCE (% of ORBIT)	SITE OF ORIGIN	ELEV. (m)	ASPECT. (DEG)	SLOPE (%)
6	43	136	Crowsnest Pass Area	1900	200	8
14	23	122	Crowsnest Pass Area	1850	220	38
37	81	104	Crowsnest Pass Area	2220	180	33
N.A.[1]	46	157	Crowsnest Pass Area	N.A.	N.A.	N.A.
111	268	131	Crowsnest Pass Area	1840	360	55
111	272	131	Crowsnest Pass Area	1840	360	55
111	267	154	Crowsnest Pass Area	1840	360	55
115	275	104	Crowsnest Pass Area	1950	315	45
117	313	107	Crowsnest Pass Area	1980	180	20
117	315	115	Crowsnest Pass Area	1980	180	20
191	588	164	Whistler Mt.(Jasper)	2270	90	40

[1] N.A. = unknown

(Table 4; Figure 1). No trends in emergence were noted based on elevation, aspect or slope.

4.3 EXPERIMENT 3 SALINITY TESTS

There were highly significant differences in emergence among accessions and among the four salt types (Table 5). However, there was no significant Accession X Salt interaction. Overall, emergence was highest in the mixture and Na_2SO_4 solutions, while the lowest emergence was in the NaCl solution (Table 6). Selected wheatgrass accessions emerged best in the mixed salt and Na_2SO_4 solutions, while Orbit had the lowest emergence in the Na_2SO_4 solution and the highest emergence in the $MgSO_4$ solution. In the mixed salt and Na_2SO_4 solutions, both selected and non-selected accessions had considerably higher emergence than Orbit or Revenue. Emergence of selected accessions equaled that of Orbit in $MgSO_4$ and NaCl solutions, while the emergence of the non-selected equaled Revenue in these salt solutions.

Over the four salt solutions, the selected accessions had higher emergence than either control (Table 7). With one exception, the selected accessions had a higher overall emergence than the non-selected accessions. Of the controls, slender wheatgrass (Revenue) had significantly lower emergence than tall wheatgrass (Orbit).

4.4 EXPERIMENT 4 PROGENY TESTS

The mean emergence of the selected accessions under saline conditions decreased from the first to the second generation but emergence was still greater than the population as a whole (Table 8). Observed response (R) to selection was 69% (of Orbit) and the selection differential (S) was 102%. These values gave a realized heritability estimate of 68 $\pm$ 48%. Salt tolerance in this slender wheatgrass population, then, was mod-

Table 4. Site, plant identification, mean emergence (N=3) in a 15 mS/cm solution of NaCl (expressed as a percent of Orbit tall wheatgrass control) and description of original collection site of selected accessions of alpine bluegrass.

SITE NO.	PLANT ID.	EMERGENCE (% of ORBIT)	SITE OF ORIGIN	ELEV. (m)	ASPECT (DEG)	SLOPE (%)
6	2	136	Crowsnest Pass	1900	200	8
9	19	100	Crowsnest Pass	1950	190	25
61	782	106	Junction Mtn.	2280	0	0
110	1005	108	Crowsnest Pass	1880	360	55
110	1006	119	Crowsnest Pass	1880	360	55
110	1007	108	Crowsnest Pass	1880	360	55
111	1016	102	Crowsnest Pass	1830	360	55
114	1036	113	Crowsnest Pass	2130	135	50
114	1038	102	Crowsnest Pass	2130	135	50
118	1050	102	Crowsnest Pass	1900	315	45
119	1057	108	Crowsnest Pass	1820	0	0
119	1059	119	Crowsnest Pass	1820	0	0
119	1060	108	Crowsnest Pass	1820	0	0
119	1063	119	Crowsnest Pass	1820	0	0
129	1124	111	Crowsnest Pass	2350	225	70
129	1131	111	Crowsnest Pass	2350	225	70
130	1149	100	Crowsnest Pass	2340	225	50
131	1151	100	Crowsnest Pass	2300	225	50
131	1154	108	Crowsnest Pass	2300	225	50
133	1171	104	Crowsnest Pass	2200	225	55
133	1173	117	Crowsnest Pass	2200	225	55
133	1175	117	Crowsnest Pass	2200	225	55
135	1202	108	Crowsnest Pass	1900	0	0
135	1211	100	Crowsnest Pass	1900	0	0
136	1218	117	Crowsnest Pass	1850	0	0
136	1221	107	Crowsnest Pass	1850	0	0
139	1252	100	Crowsnest Pass	1760	360	10
141	1268	107	Crowsnest Pass	1750	0	0
141	1269	100	Crowsnest Pass	1750	0	0
141	1271	107	Crowsnest Pass	1750	0	0
146	1292	100	Lake Louise	2080	90	20
147	1302	114	Lake Louise	2050	90	20
150	1324	124	Lake O'Hara	2270	180	5
153	1344	103	Lake O'Hara	2390	225	80
154	1354	103	Lake O'Hara	2455	180	80
154	1360	103	Lake O'Hara	2455	180	80
158	1384	114	Lake O'Hara	2480	180	65

continued...

Table 4. Concluded

SITE NO.	PLANT ID.	EMERGENCE (% of ORBIT)	SITE OF ORIGIN	ELEV. (m)	ASPECT (DEG)	SLOPE (%)
158	1386	103	Lake O'Hara	2480	180	65
159	1391	134	Lake O'Hara	2410	180	75
160	1402	103	Lake O'Hara	2350	180	75
161	1408	114	Lake O'Hara	2300	270	75
162	1414	134	Lake O'Hara	2240	180	65
166	1454	130	Lake O'Hara	2050	180	20
169	1484	130	Burgess Mtn.	2470	90	110
170	1502	114	Burgess Mtn.	2480	0	0
172	1526	105	Burgess Mtn.	2400	270	65
173	1535	130	Burgess Mtn.	2390	270	65
176	1579	115	Burgess Mtn.	2250	270	65
176	1580	146	Burgess Mtn.	2250	270	65
176	1581	115	Burgess Mtn.	2250	270	65
176	1585	100	Burgess Mtn.	2250	270	65
178	1586	108	Burgess Mtn.	2165	0	0
178	1587	123	Burgess Mtn.	2165	0	0
178	1589	108	Burgess Mtn.	2165	0	0
178	1590	108	Burgess Mtn.	2165	0	0
179	1596	100	Burgess Mtn.	2150	270	45
179	1597	108	Burgess Mtn.	2150	270	45
179	1598	125	Burgess Mtn.	2150	270	45
179	1599	133	Burgess Mtn.	2150	270	45
180	1605	125	Burgess Mtn.	2140	270	45
180	1606	167	Burgess Mtn.	2140	270	45
180	1607	158	Burgess Mtn.	2140	270	45
180	1613	100	Burgess Mtn.	2140	270	45
180	1615	133	Burgess Mtn.	2140	270	45
181	1620	100	Burgess Mtn.	2110	270	45
185	1657	100	Burgess Mtn.	1885	0	0
186	1667	100	Burgess Mtn.	1865	0	0
186	1669	171	Burgess Mtn.	1865	0	0
186	1670	214	Burgess Mtn.	1865	0	0
186	1672	129	Burgess Mtn.	1865	0	0
186	1673	100	Burgess Mtn.	1865	0	0
187	1677	171	Burgess Mtn.	1840	0	0

Table 5. Sources of variation, degrees of freedom, ANOVA sums of squares, and F value after 21 days emergence of slender wheatgrass accessions.

Source	DF	ANOVA SS	F Value
Block	5	3 896	
Salt	3	55 661	27.7 **
Main Plot Error	15	10 042	
Accession	15	122 207	36.3 **
Accession X Salt	45	11 055	1.1 ns
Subplot Error	300	67 262	

** significant at 0.01 level, ns - not significant at 0.05 level of probability

Table 6. Mean percent emergence (N=6) of slender wheatgrass accessions in four salt solutions at 15 mS/cm.

	Percent Emergence				
Salt	Mean	Orbit Control	Revenue Control	Selected Accessions	Non-selected Accessions
Mixture	84	75	33	97	80
Na_2SO_4	80	62	53	95	75
$MgSO_4$	68	81	60	81	61
NaCl	54	72	33	70	44

Table 7. Mean percent emergence (N=24) in four 15 mS/cm salt solutions of slender wheatgrass accessions compared with Orbit tall wheatgrass and Revenue slender wheatgrass controls.

Site No.	Mean Percent Emergence	REGWF Grouping[1]	Selection Status
315	89	A	Selected
275	88	AB	Selected
46	88	AB	Selected
63	87	AB	Not Selected
267	86	AB	Selected
588	84	AB	Selected
313	84	AB	Selected
35	83	AB	Not Selected
220	82	AB	Not Selected
277	73	BC	Not Selected
Orbit	69	C	Control
271	66	C	Not Selected
288	47	D	Not Selected
Revenue	45	D	Control
32	43	D	Not Selected
286	38	D	Not Selected

[1] Means with the same letter are not significantly different (REGWF test)

Table 8. Mean emergence of first (N=3) and second generation (N=6) selected accessions of slender wheatgrass under saline conditions expressed as a percentage of the emergence of Orbit tall wheatgrass.

	Emergence (% of Orbit)	
Accession	First Generation	Second Generation
23	122.7	130.0
43	136.3	83.3
46	156.8	123.3
81	104.2	86.7
267	154.4	130.0
268	130.9	53.3
272	130.9	60.0
275	104.2	113.3
313	107.8	110.0
315	115.5	86.7
588	163.9	90.0
Mean	129.8	97.0
Population Mean	27.8†	27.8
R	--	69.2
S	102.0	--

† Population mean was obtained from Experiment 2 (data not shown in this report).

erately heritable and improvement in tolerance should be possible through a selection process.

5. DISCUSSION

In a preliminary experiment comparing the emergence of 12 common agronomic grass varieties, tall wheatgrass (Orbit) showed an emergence far superior to the other varieties. Based on this finding, Orbit was chosen as the control for all subsequent testing. At the three salt concentrations tried in Experiment 1, Orbit showed no reduction in emergence between 10 mS/cm and 15 mS/cm, but did show reduced emergence at 20 mS/cm. Therefore, a salt solution with a concentration equivalent to a conductivity of 15 mS/cm was chosen for all further testing.

When AEC accessions of alpine bluegrass and slender wheatgrass were screened, it was not expected that their emergence in a saline environment would equal or exceed the tolerance of the Orbit control. However, comparisons of the tested accessions produced a skewed distribution for both species with a tail representing those accessions having a salt tolerance greater than the control (Figure 2 and Figure 3). This suggested that a small percentage of the accessions of the native east slope populations of both species comprise salt tolerant plants.

All except one of the salt tolerant slender wheatgrass accessions originated from the Crowsnest Pass area of southwestern Alberta, whereas all except one of the tolerant alpine bluegrass collections originated from the Crowsnest Pass and areas around Field on the Alberta-British Columbia border. Although the collections screened originated from areas throughout the Rocky Mountains and foothills south of Jasper, accessions which had a high salt tolerance for emergence originated from very specific locations (Figure 1). This suggests a certain degree of local specificity for this trait and may indicate ecotypic adaptation to specific environments.

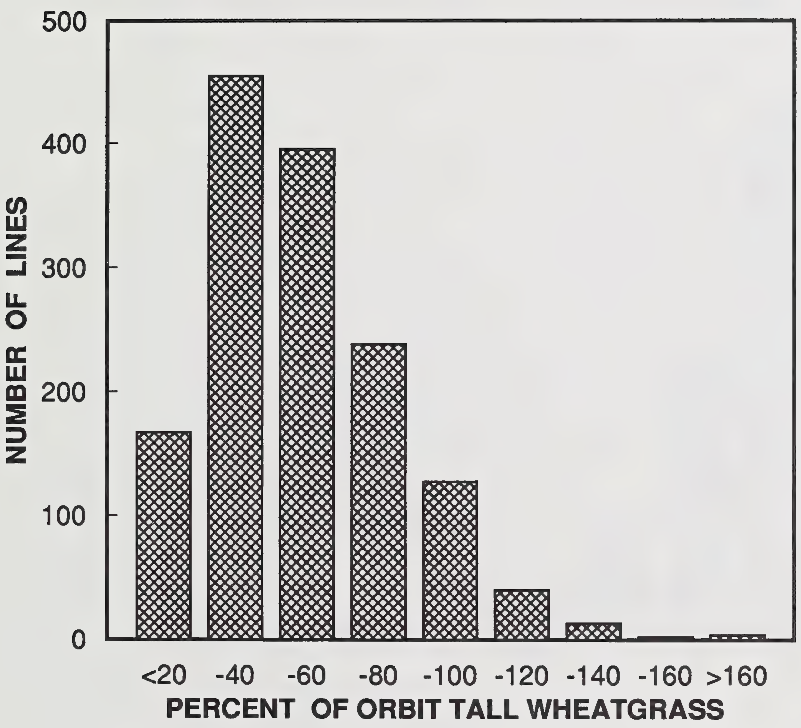

Figure 2. Emergence of 1441 accessions of alpine bluegrass at 15 mS/cm as a percentage of Orbit tall wheatgrass

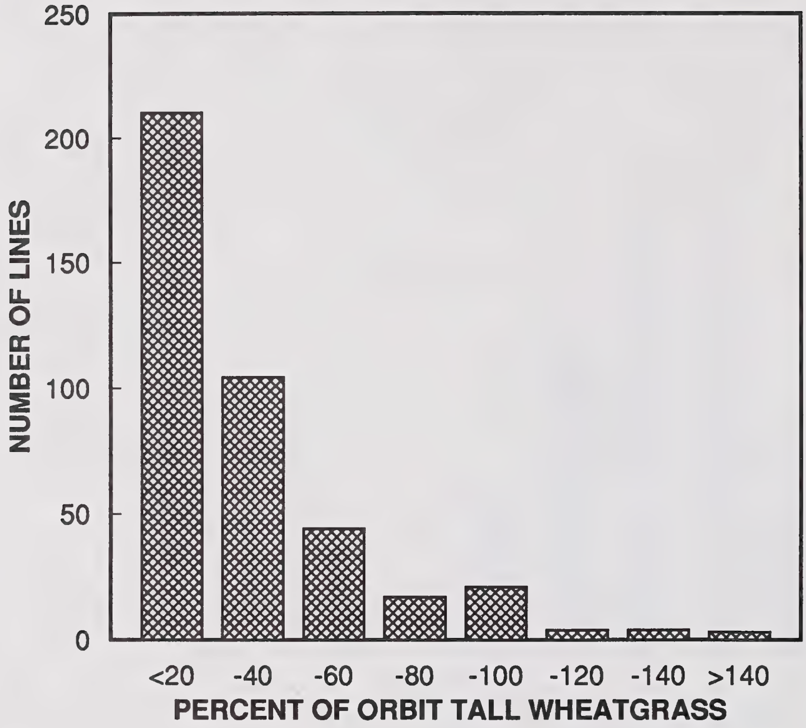

Figure 3. Emergence of 406 accessions of slender wheatgrass at 15 mS/cm as a percentage of Orbit tall wheatgrass

The considerable differences in the response of test plants to the four salt types indicates that some salts are more toxic than others. However, the absence of an interaction between salt type and accession tested indicates that the selections made in a medium salinized by one salt species will also do well in a medium salinized by a different salt. That the selected accessions outperformed non-selected accessions in this experiment is another indication of the validity of the selections made.

The estimate of realized heritability (68%) shows that plant genotype was important and it should be possible to improve salinity tolerance in slender wheatgrass by selection. Environmental variation probably caused the decrease in mean emergence of the selected accessions from the first to second generation. However, the assumption that the overall population mean did not change from one generation to the next should be valid because there were many more accessions in the total population than in the selected population. The greater number of accessions would compensate for fluctuations in emergence of individual accessions. Heritability estimates of salinity tolerance in other species vary. For example, yield of barley under saline conditions had a heritability of 28% (Norlyn 1984) while estimates as high as 89% have been reported for salinity tolerance in rice (Moeljopawiro and Ikehashi 1981). Variation in heritability of salinity tolerance is due to the use of different species and different methods of measuring salinity tolerance. In experiments using germination or emergence of seeds under saline conditions, heritability of salt tolerance varies from 38% in cotton (Ledbetter 1986) to 50% in alfalfa (Allen et al. 1985). These estimates are both lower than the estimate obtained for emergence of slender wheatgrass in the present experiment. Our higher estimate may be due to the use of a different species or to the presence of

greater variability for salt tolerance in the population studied.

The accessions of native slender wheatgrass and alpine bluegrass were selected for salt tolerance based on their ability to emerge under saline conditions. It is hoped that they will also show good growth and vigor during later stages of the life cycle. Of the forages, Orbit is ranked as the most salt tolerant (Maas 1984), but it has a few disadvantages as it is slow to establish and is not drought-tolerant (Elliott and Bolton 1979). As our native accessions can withstand extreme conditions, it is believed that we may have some salt tolerant accessions which will prove valuable for both agriculture and reclamation use in Alberta.

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RECLAMATION RESEARCH REPORTS

1. **RRTAC 79-2: Proceedings: Workshop on Native Shrubs in Reclamation. P.F. Ziemkiewicz, C.A. Dermott and H.P. Sims (Editors). 104 pp. No longer available.**

The Workshop was organized as the first step in developing a Native Shrub reclamation research program. The Workshop provided a forum for the exchange of information and experiences on three topics: propagation; outplanting; and, species selection. Seven papers and the results of three discussion groups are presented.

2. **RRTAC 80-1: Test Plot Establishment: Native Grasses for Reclamation. R.S. Sadasivaiah and J. Weijer. 19 pp. No longer available.**

The report details the species used at three test plots in Alberta's Eastern Slopes (one at Caw Creek Ridge and two at Cadomin). Site preparation, experimental design, and planting method are also described.

3. **RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp. $10.00**

This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

4. **RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier (Editors). 160 pp. $10.00**

Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

5. **RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker and D.F. Polster. 2 vols, 541 pp. No longer available; replaced by RRTAC 89-4.**

Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

6. **RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp. $10.00**

This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

7. **RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch and G. Lutwick (Editors). 253 pp. $10.00**

Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

8. **RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp. $10.00**

Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

9. **RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp. $5.00**

This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

10. **RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp. No longer available**

Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

11. **RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp. No longer available.**

Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

12. **RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz (Editor). 123 pp. $10.00**

Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

13. **RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp. No longer available.**

This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

14. **RRTAC 84-1: Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols, 1549 pp. $20.00**

Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

15. **RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp. $10.00**

This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

16. **RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

17. **RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols, 676 pp. $10.00**

This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

18. **RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz (Editor). 416 pp. $10.00**

Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

19. **RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

20. **RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp. $10.00**

The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

21. **RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp. No longer available.**

Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

22. **RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp. $5.00**

In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

23. **RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp. $10.00**

This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

24. **RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 71 pp. $10.00**

This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

25. **RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp. $5.00**

The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta.

26. **RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp. $5.00**

This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

27. **RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

28. **RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp. No longer available.**

This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

29. **RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp. No longer available.**

Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

30. **RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp. $10.00**

This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

31. **RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (Compiler). 218 pp. No longer available.**

Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

32. **RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

33. **RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp. $10.00**

The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

34. **RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp. $10.00**

The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

35. **RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp. No longer available.**

The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

36. **RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp. $5.00**

This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

37. **RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp. No longer available.**

This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

38. **RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps. $10.00**

The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

39. **RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp. $10.00**

The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

40. **RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp. $10.00**

This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

41. **RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp. $5.00**

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

42. **RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix. $10.00**

The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

43. **RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp. $10.00**

Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

44. **RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp. $10.00**

The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their un-inoculated counterparts.

45. **RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp. $10.00**

This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

46. **RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp. $10.00**

The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

47. **RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp. No longer available.**

This annual report describes the expenditure of $500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

48. **RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp. $5.00**

Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

49. **RRTAC 88-8: Alberta Forest Service Watershed Management Field and Laboratory Methods. A.M.K. Nip and R.A. Hursey. 4 Sections, various pagings. $10.00**

Disturbances such as coal mines in the Eastern Slopes of Alberta have the potential for affecting watershed quality during and following mining. The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin. There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

50. **RRTAC 88-9: Computer Analysis of the Factors Influencing Groundwater Flow and Mass Transport in a System Disturbed by Strip Mining. F.W. Schwartz and A.S. Crowe. 78 pp. $10.00**

Work presented in this report demonstrates how a groundwater flow model can be used to study a variety of mining-related problems such as declining water levels in areas around the mine as a result of dewatering, and the development of high water tables in spoil once resaturation is complete. This report investigates the role of various hydrogeological parameters that influence the magnitude, timing, and extent of water level changes during and following mining at the regional scale. The modelling approach described here represents a major advance on existing work.

51. **RRTAC 88-10: Review of Literature Related to Clay Liners for Sump Disposal of Drilling Wastes. D.R. Pauls, S.R. Moran and T. Macyk. 61 pp. $5.00**

The report reviews and analyses the effectiveness of geological containment of drilling waste in sumps. Of particular importance was the determination of changes in properties of clay materials as a result of contact with highly saline brines containing various organic chemicals.

52. **RRTAC 88-11: Highvale Soil Reconstruction Project: Five Year Summary. D.N. Graveland, T.A. Oddie, A.E. Osborne and L.A. Panek. 104 pp. $10.00**

This report provides details of a five year study to determine a suitable thickness of subsoil to replace over minespoil in the Highvale plains coal mine area to ensure return of agricultural capability. The study also examined the effect of slope and aspect on agricultural capability. This study was funded and managed with industry assistance.

53. **RRTAC 88-12: A Review of the International Literature on Mine Spoil Subsidence. J.D. Scott, G. Zinter, D.R. Pauls and M.B. Dusseault. 36 pp. $10.00**

The report reviews available engineering literature relative to subsidence of reclaimed mine spoil. The report covers methods for site investigation, field monitoring programs and lab programs, mechanisms of settlement, and remedial measures.

54. **RRTAC 89-1: Reclamation Research Annual Report - 1988. 74 pp. $5.00**

This annual report describes the expenditure of $280,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

55. **RRTAC 89-2: Proceedings of the Conference: Reclamation, A Global Perspective. D.G. Walker, C.B. Powter and M.W. Pole (Compilers). 2 Vols., 854 pp. $10.00**

Over 250 delegates from all over the world attended this conference held in Calgary in August, 1989. The proceedings contains over 85 peer-reviewed papers under the following headings: A Global Perspective; Northern and High Altitude Reclamation; Fish & Wildlife and Rangeland Reclamation; Water; Herbaceous Revegetation; Woody Plant Revegetation and Succession; Industrial and Urban Sites; Problems and Solutions; Sodic and Saline Materials; Soils and Overburden; Acid Generating Materials; and, Mine Tailings.

56. **RRTAC 89-3: Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil. M.P. Sharma. 38 pp. $5.00**

Bromacil and Tebuthiuron were commonly used soil sterilants on well sites, battery sites and other industrial sites in Alberta where total vegetation control was desired. Activated charcoal was found to be effective in binding the sterilants in greenhouse trials. The influence of factors such as herbicide:charcoal concentration ratio, soil texture, organic matter content, soil moisture, and the time interval between charcoal incorporation and plant establishment were evaluated in the greenhouse.

57. **RRTAC 89-4: Manual of Plant Species Suitability for Reclamation in Alberta - 2nd Edition. Hardy BBT Limited. 436 pp. $10.00**

This is an updated version of RRTAC Report 80-5 which describes the characteristics of 43 grass, 14 forb and 34 shrub and tree species which make them suitable for reclamation in Alberta. The report has been updated in several important ways: a line drawing of each species has been added; the range maps for each species have been redrawn based on an ecosystem classification of the province; new information (to 1990) has been added, particularly in the sections on reclamation use; and the material has been reorganized to facilitate information retrieval. Of greatest interest is the performance chart that precedes each species and the combined performance charts for the grass, forb, and shrub/tree groups. These allow the reader to pick out at a glance species that may suit their particular needs. The report was produced with the assistance of a grant from the Recreation, Parks and Wildlife Foundation.

58. **RRTAC 89-5: Battle River Soil Reconstruction Project Five Year Summary. L.A. Leskiw. 188 pp. $10.00**

This report summarizes the results of a five year study to investigate methods required to return capability to land surface mined for coal in the Battle River area of central Alberta. Studies were conducted on: the amounts of subsoil required, the potential of gypsum and bottom ash to amend adverse soil properties, and the effects of slope angle and aspect. Forage and cereal crop growth was evaluated, as were changes in soil chemistry, density and moisture holding characteristics.

59. **RRTAC 89-6: Detailed Sampling, Characterization and Greenhouse Pot Trials Relative to Drilling Wastes in Alberta. T.M. Macyk, F.I. Nikiforuk, S.A. Abboud and Z.W. Widtman. 228 pp. $10.00**

This report summarizes a three-year study of the chemistry of freshwater gel, KCl, NaCl, DAP, and invert drilling wastes, both solids and liquids, from three regions in Alberta: Cold Lake, Eastern Slopes, and Peace River/Grande Prairie. A greenhouse study also examined the effects of adding various amounts of waste to soil on grass growth and soil chemistry. Methods for sampling drilling wastes are recommended.

60. **RRTAC 89-7: A User's Guide for the Prediction of Post-Mining Groundwater Chemistry from Overburden Characteristics. M.R. Trudell and D.C. Cheel. 55 pp. $5.00**

This report provides the detailed procedure and methodology that is required to produce a prediction of post-mining groundwater chemistry for plains coal mines, based on the soluble salt characteristics of overburden materials. The fundamental component of the prediction procedure is the geochemical model PHREEQE, developed by the U.S. Geological Survey, which is in the public domain and has been adapted for use on personal computers.

61. **RRTAC 90-1: Reclamation Research Annual Report - 1989. 62 pp. $5.00**

This annual report describes the expenditure of $480,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

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